*spot*lights

Moulin Bleu

Most of the time, new results in climate science seem to be bad news. Sea levels are rising faster than previously thought. The atmosphere is trapping more heat. More species are threatened. Ever more disastrous outcomes will lead to even greater warming.

But two Los Alamos scientists, working with an international team from other government laboratories and universities, recently discovered that at least one aspect of the warming climate is actually *less* of a concern than previously believed. Stephen Price and Matthew Hoffman of Los Alamos, working with Mauro Perego of Sandia National Laboratories, carried out supercomputer simulations of the Greenland ice sheet with two Department of Energy-supported models. The simulations were based upon an understanding derived from recent field measurements of the Greenland ice sheet carried out by other members of the international collaboration. Taken together with contributions from two European models, the simulations showed that future increases in meltwater running beneath the ice sheet will have a smaller-than-expected influence on ushering glacial ice into the ocean.

For the past decade, glaciologists have debated whether or not such meltwater could accelerate the demise of the Greenland ice sheet and therefore the pace of sea level rise overall. Meltwater flowing along the surface ice can dive into moulins—vertical shafts that convey water to the base of the ice sheet, where it spreads across the underlying bed. As the conventional thinking goes, this water ought to lubricate the interface between the ice and the ground, thereby causing glaciers to flow more quickly into the ocean. But just how significant this lubricating effect ought to be has been an issue of contention.

Now, for the first time, detailed, credible predictions of the contribution of meltwater lubrication to sea level rise are available. The research revealed that by the end of the century the effect will add at most 4 percent to the overall sea level rise from Greenland.

"By the year 2100, Greenland's contribution to global sea level rise is projected to be about 6 centimeters, with the majority of that attributable to increased melting alone," Price says, referring to results based on a probable greenhouse gas emissions scenario during that time period. "But the additional sea level rise that's caused by meltwater lubrication will be only a few millimeters." Price says that by 2200, Greenland's estimated contribution to sea level rise from melting should be about 17 centimeters, with less than one additional centimeter due to

Meltwater on the Greenland ice sheet forms surface flows that can eventually dive into moulins. These moulins deliver water to the base of the ice sheet, where it marginally affects the rate at which glaciers move to the sea.
CREDIT: MATTHEW HOFFMAN/LANL

the meltwater lubrication effect. And sometimes, increased meltwater can actually inhibit the flow of a glacier.

As the Greenland summer presses on, larger flows of meltwater open up progressively wider tunnels at the bottom of the ice. When summer ends and less meltwater flows through the oversized tunnels, the water is able to drain more efficiently without lubricating the ice-rock interface, thereby reducing the motion of the ice.

When winter arrives, the mass of the glacier crushes down into the empty meltwater channels, such that when the flows resume in the spring, the underlying drainage network is insufficient to accommodate all the water. The back-pressure of the non-draining water tends to lift the glacier, reinstating the lubrication effect and helping the glacier move seaward. The lubrication effect persists until the underlying water channels once again outgrow what the flows require, allowing the water to drain without lifting the glacier. The new computer simulation accounts for both annual effects on the ice flow—slowing in the fall and accelerating in the spring—and yields a compromise outcome in which the meltwater from moulins only minimally hastens the movement of ice into the sea.
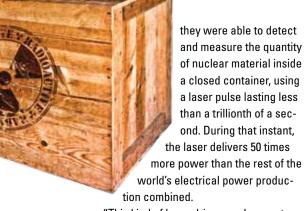
Should everyone breathe a collective sigh of relief? Maybe just a little. As Hoffman says, "I find it reassuring to put a box around this particular process and show it to be not as serious as was once thought. This allows us to turn our attention to better understanding other potential contributions to sea level rise from glaciers and ice sheets." LDRD

How to Spot a Nuke

The United States needs a fast, reliable screening system to scan for nuclear materials like uranium and plutonium at ports, borders, and other sensitive areas. Los Alamos National Laboratory recently demonstrated a new technology that does exactly that.

Andrea Favalli and Martyn Swinhoe of the Lab's Nuclear Safeguards Science and Technology group led an experiment in which

they were able to detect and measure the quantity of nuclear material inside a closed container, using a laser pulse lasting less than a trillionth of a second. During that instant, the laser delivers 50 times more power than the rest of the world's electrical power production combined.

"This kind of laser-driven nuclear-material detection was just an idea," says Favalli. "No one knew if it could actually be done until we worked out the details, fabricated the parts, and performed the test."

Favalli, Swinhoe, and their team focused the Lab's powerful TRIDENT laser onto a thin plastic target, concentrating the incredibly high-energy burst of light into a spot less than a thousandth the diameter of a human hair. The plastic had been previously deuterated, meaning that its hydrogen atoms were replaced with deuterium, a heavier isotope of hydrogen with a loosely bound proton-neutron pair comprising its nucleus. The laser blasts the deuterium nuclei off the plastic in a high-speed beam that strikes a second target made of metal. When the deuterium nuclei strike the metal target, they split apart and shake loose a tremendous, billionth-of-a-second shower of neutrons traveling at up to half the speed of light. These high-energy neutrons, originating from both the deuterium and the metal nuclei, penetrate the closed container being scanned.

Normally, the neutron burst would be detected after passing through the container and that's the end of the story. However, when nuclear materials are present, the neutron burst will cause some nuclear fission reactions within the material. (Such nuclear material is always in a noncritical configuration unless deliberately detonated in a bomb, so these additional fissions pose no danger; a complete nuclear weapon can be safely scanned in this way.) The fissions produce a wave of additional neutrons, called delayed neutrons, which can be

detected for several seconds after the laser-driven burst. It is these delayed neutrons that reveal the presence of illicit nuclear materials.

Laser experts within the research group are confident that the entire laser-driven neutron detection system can be shrunk down to fit within the back of a shipping truck, making it portable enough to distribute to border points and other locations where needed. The technique may also find applications in scientific research as a convenient neutron source for studying the effects of radiation on materials and electronic systems, among other uses. LDRD

Explosives Going Dark

In addition to developing field-deployable technology for detecting nuclear materials [see previous Spotlight article], Los Alamos also contributes to field-deployable technology for detecting conventional explosives. Research carried out by a team from the U.S. Air Force Academy recently showed that an enhanced biomarker, developed at Los Alamos, can rapidly screen for certain dangerous explosives and toxins—to the benefit of military and civilian security officers, first responders, and humanitarian remediation workers.

The biomarker is a type of green fluorescent protein, or GFP. Normally used in biological research, GFP emits a characteristic green glow when exposed to blue light, making it easy to detect cellular components tagged with the marker. GFP can also be triggered to glow green by exposure to 280-nanometer wavelength ultraviolet (UV) light—a feature that has been largely ignored because UV light causes cellular damage. However, in a non-biological context, this feature can be exploited to indicate the presence of nitroorganic high explosives, including TNT and RDX. The explosives inhibit the UV-excitation mechanism, so

when they are added to UV-illuminated GFP, the green glow shuts off—an event easily recognized in a laboratory or field setting.

Los Alamos biologists Andrew Bradbury, Geoff Waldo, and Csaba Kiss created an enhanced version of GFP, called eCGP123 ("enhanced consensus green protein"), capable of withstanding the rigors of field-deployment. Unlike other materials-sensing molecules, which can be rendered ineffective by exposure to common chemicals or elevated temperatures, eCGP123 is highly stable—and it responds strongly to each of the six explosives tested. It can be produced inexpensively in large quantities and may even be reusable as well: an hour after being exposed to explosives in vapor form, eCGP123 resumed its green glow.

Early indications suggest that the class of organic materials capable of inhibiting the UV excitation of GFP likely includes not only explosives, but a number of poisons and chemical-weapon nerve agents, too. LDRD

—Craig Tyler

Thermostability galore: fluorescent protein eCGP123 continues to glow even when briefly boiled.